As older persons in the intensive care unit increasingly require long-term mechanical ventilation, accurate indications of readiness for weaning from ventilatory support are needed to avoid premature extubation.

**OBJECTIVE**  To describe temporal changes in pulmonary and systemic variables in older adults receiving long-term mechanical ventilation.

**METHODS** After 3 days of unsuccessful attempts at weaning from ventilatory support, 10 trauma and surgical patients more than 60 years old were monitored daily. Previously reported predictors of the duration of mechanical ventilation and weaning outcome were measured, including hemodynamic and gas exchange variables, oxygen cost of breathing, and the score on the Burns Weaning Assessment Program.

**RESULTS** The 6 patients who could be weaned from ventilatory support were younger (median age, 71.5 years) than the 4 patients who could not be weaned (median age, 80 years). Patients who could be weaned were ready for weaning by day 11 of their stay in the intensive care unit and required an additional 5.5 days of mechanical ventilation; those who could not be weaned were not ready for weaning until day 17. All patients initially had increases in oxygen consumption during weaning; those who were successfully weaned had decreases before extubation. Respiratory rate, maximal inspiratory pressure, the ratio of PaO₂ to fraction of inspired oxygen, and mean arterial pressure were higher in patients who could be weaned, and oxygen cost of breathing and central venous pressure were lower.

**CONCLUSION** Further study of weaning in older adults is warranted. (American Journal of Critical Care. 2002;11:369-377)
Although age alone is not a predictor of the outcome of mechanical ventilation, older patients fare more poorly than do younger patients. In a recent study of 4315 older patients who had nonemergent, noncardiac surgery, increasing age was associated with a significantly higher risk for bacterial pneumonia, respiratory failure requiring mechanical ventilation, longer hospital length of stay, and in-hospital mortality.

Because of the increasing number of older patients who require long-term mechanical ventilation, clinicians need accurate and reliable predictors of readiness for weaning in these patients. The Third National Study Group on Weaning From Mechanical Ventilation, sponsored by the American Association of Critical-Care Nurses, published a series of articles devoted to the advancement of weaning science. For patients receiving long-term mechanical ventilation, the group stressed the need for studies describing the clinical course of weaning so that weaning might be better understood as a process. Because of the complex and interactive nature of factors that affect readiness for weaning in patients receiving long-term mechanical ventilation, the study group also recommended that further research should be directed toward exploring potential interactions between pulmonary and multidimensional, systemic determinants of weaning.

The study group defined long-term mechanical ventilation as the need for mechanical ventilation for 3 or more days. On the basis of this definition, most older trauma and high-risk surgical patients would easily qualify as patients receiving long-term mechanical ventilation. Clinicians often do not attempt to wean these patients from mechanical ventilation within this time frame because the patients need large amounts of intravenous crystalloid and blood cell products, analgesia, and sedation. However, once older patients’ hemodynamic condition, gas exchange, organ function, and fluid balance are stable, many are weaned successfully. Of greater concern is the smaller group of older patients who cannot be weaned once they have achieved physiological homeostasis.

The purpose of the pilot study described in this article was to describe the clinical course of weaning in critically ill older adults who were receiving long-term mechanical ventilation in order to determine whether differences exist between patients who can be weaned and those who cannot and to determine whether systemic factors play a role in these differences.

Methods

The informed consent protocol for the study was approved by the nursing research committee and the institutional review board at Case Western Reserve University, MetroHealth Medical Center, a 750-bed, level I trauma center in Cleveland, Ohio. Informed consent was obtained from each patient’s legal next of kin; there were no refusals for consent. Patients eligible for the study were 60 years or older, were admitted to the surgical intensive care unit (SICU) after surgery and/or for management of traumatic injuries, and were receiving mechanical ventilation for the first time during the current hospitalization. After the SICU admission, all eligible patients were monitored for weaning progress. Convenience sampling was used to enroll patients in the study.

The decision to initiate weaning from mechanical ventilation was made by the attending physician. According to unit protocol, weaning decisions were based on the following weaning parameters: spontaneous respirations (acceptable, <35/min), maximal inspiratory pressure (MIP; acceptable, <-25 cm), and the rapid-shallow-breathing index developed by Yang and Tobin, defined as the ratio of respiratory frequency to tidal volume (f/Vt) measured in liters per breaths per minute (acceptable, <105). Once a physician decided to initiate weaning, a collaborative process between the physician, nurses, and respiratory therapists would be used to facilitate weaning, according to a unit-based weaning protocol (see following).

Active weaning was a priori defined by the study investigators as any change in ventilator settings intended to promote forward progress in weaning from mechanical ventilation, including changes in ventilator mode or decreases in ventilator rate, fraction of inspired oxygen (Fio2), pressure support, or positive end-expiratory pressure (PEEP). No changes in ventilator settings to promote weaning were made until the Fio2 was reduced to 0.50, PEEP was decreased to 5 cm, and intravenous vasopressor support was no longer required. Patients were deemed eligible for enrollment in the study when 3 consecutive days of active attempts at weaning were unsuccessful. Also considered eligible were patients who were extubated during this 3-day period and then reintubated within 24 hours. Thus, for each patient, day 1 of the study represented the third day of an active and unsuccessful attempt at weaning.

SICU Weaning Protocol

The SICU weaning protocol was initiated if the patient met the following conditions: minute ventilation 15 L/min or less, Fio2 0.50 or less, PaO2 60 mm Hg or greater or arterial oxygen saturation determined by pulse oximetry 90% or greater, PEEP 5 cm H2O or less, respirations less than 35/min, heart rate less than 140/min, and no use of vasopressors (low-dose...
A spontaneous breathing trial was performed for 1 to 2 hours by using ventilator flow-by; "flow-by" is a trademarked method of delivering a predetermined flow of gas to the patient before patient-initiated inspiratory breaths, including pressure support and apnea, in order to reduce the patient's work necessary to trigger the ventilator (Puritan-Bennett, Carlsbad, Calif / Mallinckrodt, St. Louis, Mo). Patients were monitored for low tidal volumes (<3 mL/kg), tachypnea, and apnea. Patients were also observed for evidence of respiratory fatigue and oxygen desaturation and for the following changes: respirations greater than 35/min, heart rate greater than 140/min or a greater than 20% change from baseline, oxygen saturation less than 90% by pulse oximetry, and systolic blood pressure less than 80 mm Hg or greater than 200 mm Hg. When any of these changes occurred and was sustained, the trial was stopped. Mechanical ventilatory support was restarted for any patient who did not pass the weaning trial, and the patient was evaluated the next morning. When gas exchange was adequate, as determined by arterial blood gas analysis, the respiratory therapist obtained clearance from a physician to extubate the patient.

Some attending physicians chose not to use the weaning protocol and opted for a "slow wean." In a slow wean, respiratory rate was decreased gradually, and decisions about weaning were made by the physician based on the results of arterial blood gas analysis, fluid balance, findings on chest radiographs, and estimated quantity of secretions.

**Study Variables**

Participants were monitored daily until they were successfully weaned from and did not require mechanical ventilation for 24 hours or up to a maximum of 14 days. Data were collected after morning rounds and weaning decisions were made. Only clinically available data were used. Data were either measured in real time or were obtained from the medical record for the documented time weaning attempts were made. Time of weaning was determined from the respiratory therapist’s progress notes.

**Burns Weaning Assessment Program.** The Burns Weaning Assessment Program (BWAP),10-12 a 26-item checklist of general and respiratory factors, was used to assess readiness for weaning. Real-time measurements were used to determine BWAP scores. Each item was marked yes, no, or not assessed. The final BWAP score was the number of yes answers divided by 26; higher scores should indicate greater readiness for weaning. General factors consisted of systemic, multidimensional, and physiological parameters that may affect readiness for weaning, including hemodynamic stability, factors that increase metabolic rate (sepsis, fever), hematocrit, hydration status, nutritional state, serum albumin level, serum levels of electrolytes, absence of bowel problems, activity level, and findings on chest radiographs. General factors also included several items representing patients’ subjective appraisals of pain control, the adequacy of sleep/rest, and level of anxiety. Patients who were able to comprehend the questions commonly responded to them with head nodding, writing, or using 1 or 2 fingers to indicate yes or no. Respiratory factors are subdivided into 5 categories: (1) gas flow and work of breathing (spontaneous respirations, breath sounds, character of secretions, presence of neuromuscular disorders, size of endotracheal tube, presence of abdominal distention, obesity, and ascites), (2) airway clearance (cough and swallowing reflexes), (3) strength (MIP, positive expiratory pressure), (4) endurance (spontaneous tidal volume per kilogram), and (5) arterial blood gases (pH, PacO2, PaO2). An interrater reliability of 95% for the BWAP scores was determined, based on a random selection of the records of 3 patients.

**Oxygen Cost of Breathing.** Oxygen cost of breathing, an estimate of the percentage of whole body oxygen consumption (V02) recruited for the work of breathing,13-15 was calculated before and after each ventilator change by using the Puritan-Bennett 7250 Metabolic Monitor (Puritan-Bennett, Carlsbad, Calif / Mallinckrodt, St. Louis, Mo). The monitor is calibrated automatically and measures V02, carbon dioxide production (VCO2), respiratory quotient, and caloric requirements. The monitor’s accuracy for measurement of V02 and VCO2 is within ±6% of predicted values.16 The monitor was calibrated after a 45-minute warm-up; a known gas mixture consisting of 5% carbon dioxide and 95% oxygen was used to calibrate the sensor. In vitro measurements of V02 and VCO2 were made by infusing 50% carbon dioxide into a patient circuit with the ventilator set to deliver 50% oxygen. Total system accuracy was ensured when the respiratory quotient, or the ratio of V02 to VCO2, was from 0.92 to 1.08. The mean coefficient of variation, used to determine the precision of measurements, was 4.1% (SD, 1.9%; range, 1.3%-9.1%). No measurements were taken when patients had endotracheal or chest tube air leaks or an FiO2 greater than 0.80 or had been given an anesthetic within the previous 6 hours.17

The oxygen cost of breathing was calculated in 3 steps. First, before any ventilator settings were changed, a V02 value was obtained every 30 minutes during a period of 2 hours for a total of 4 values; the mean of the 4 values was used at the initial V02 value. After the ventilator change, a V02 value was again obtained every 30 minutes during a period of 2 hours.
for a total of 4 values; the mean of the 4 values was used as the final \( \dot{V}_O_2 \) value. The difference between the initial and final values was then divided by the initial \( \dot{V}_O_2 \), calculated as a percentage of whole body \( \dot{V}_O_2 \).

**Multidimensional Variables.** Values for multidimensional variables were retrieved daily from each patient’s medical record. The data included the 3 interdependent dimensions of weaning that Goodnough Hanneman\(^{18}\) found were useful in predicting weaning outcome in cardiac surgery patients: (1) pulmonary mechanics, including weaning parameters (eg, spontaneous respirations and tidal volume, MIP, and the rapid-shallow-breathing index) and ventilator settings; (2) gas exchange, including results of arterial blood gas analysis and the PaO\(_2\)/FiO\(_2\); and (3) hemodynamic variables (modular monitor, Hewlett Packard, Palo Alto, Calif), including mean arterial pressure (MAP), heart rate, central venous pressure (CVP), cardiac output, cardiac index, and pulmonary artery occlusion pressure (PAOP).

On the basis of the work of Clochesy and colleagues,\(^{19-22}\) levels of serum albumin, 24-hour net fluid balance, and the presence of left ventricular dysfunction were determined by examining patients’ flow sheets and medical records. Indicators of left ventricular dysfunction included left ventricular ejection fraction less than 0.40, echocardiographic results, cardiac index less than 3.5, PAOP greater than 18 mm Hg, and clinical diagnosis of heart failure or pulmonary edema.

Distributions of variables were plotted and examined for outliers. Measures of central tendency were computed, and means, medians, and ranges are reported unless otherwise indicated. Differences between patients who were successfully weaned and those who were not were compared by using the Mann-Whitney and Wilcoxon signed ranks tests (SPSS 10.1, SPSS Inc, Chicago, Ill). A nondirectional equal to or less than .05 was considered significant.

**Results**

Seven trauma and 3 surgical patients who were admitted to the SICU were included in the study. Table 1 lists the demographic and clinical descriptors of the sample. The mean age of participants was 72.6 years (median, 76; range, 60-82). The mean age of the 6 patients who were successfully weaned during the study period was 70 years (median, 71.5; range, 60-80). Patients who could not be weaned had a statistically significant lower MIP than did patients who could not be weaned. The differences between those who could be weaned during the study period and those who could not were significant (\( Z = -2.574, P = .01 \)). The 6 patients who could be weaned had received mechanical ventilation for a mean of 11 days (median, 12.5; range, 7-15). The 4 patients who could not be weaned had received mechanical ventilatory support for a mean of 17 days (median, 17; range, 16-18).

Before entry in the study, all patients had required mechanical ventilation for a mean of 13.6 days (median, 14.5; range, 7-18). The differences between those who were weaned during the study period and those who could not be weaned were not significant (\( Z = -2.574, P = .01 \)). The 6 patients who could be weaned had received mechanical ventilation for a mean of 11 days (median, 12.5; range, 7-15). The 4 patients who could not be weaned had received mechanical ventilatory support for a mean of 17 days (median, 17; range, 16-18).

After enrollment in the study, patients who eventually could be weaned required a mean of 6 additional days of ventilatory support (median, 5.5; range, 3-11). In contrast, patients who could not be weaned required ventilatory support for the entire study period of 14 days. The median duration of overall mechanical ventilation was 17.5 days (range, 10-25) for patients who were successfully weaned and at least 30 days for patients who could not be weaned, an underestimated value because of the length of the study period itself. The differences between the 2 groups were significant (\( Z = -2.805, P = .005 \)).

Tables 2, 3, and 4 give weaning parameters, oxygenation variables, and systemic variables for the 10 patients in the sample. Initial values refer to median baseline values at the time of entry in the study. For patients who could be weaned, the final median values are the last set of values measured before extubation. For patients who could not be weaned, the final median values are the last set of values measured on day 14 of the respective study periods. Differences in initial weaning parameters between the 2 groups of patients were not significant (Table 2). For final weaning parameters, patients who were successfully weaned had a significantly higher respiratory rate (\( Z = -2.57, P = .02 \)) and a lower minute ventilation than did patients who could not be weaned (\( Z = -2.34, P = .02 \)). Patients who could not be weaned had a statistically significant lower MIP than did patients who could be weaned (\( Z = -2.13, P = .02 \)), although most clinicians would agree that this difference would not be clinically significant. Both groups of patients had improvement in f\( V/T \) values, although the difference between the groups was not significant.

Table 3 gives the oxygenation values. At the time of entry in the study, both groups of patients had increases in \( \dot{V}_O_2 \) with continued attempts at weaning. The calculated median oxygen cost of breathing as a result of these changes was 6% for patients who were weaned and 13% for 1 patient who could not be weaned. Only patients...
who were successfully weaned had a decrease in $\dot{V}O_2$ over time, although differences between groups were not significant. The median calculated oxygen cost of breathing for patients who were weaned remained at 6%; in the 3 patients who could not be weaned, the final median calculated oxygen of breathing was 4%. The $PaO_2/FIO_2$ ratio indicated that most patients had some degree of acute lung injury; however, patients who were successfully weaned had significantly better initial ($Z = -2.803, P = .005$) and final ($Z = -2.803, P = .005$) values than did patients who could not be weaned. Significant differences in initial pH values ($Z = -2.09, P = .04$) were also detected, although the patients who could not be weaned had a normalized pH.

Table 4 presents the systemic variables of the 10 patients. The patients who were successfully weaned had significantly higher initial MAPs ($Z = -2.803, P = .005$) and lower CVPs ($Z = -2.527, P = .01$) than did the patients who could not be weaned. Patients who could be weaned also had significantly higher final MAPs ($Z = -2.803, P = .005$) and lower CVPs ($Z = -2.533, P = .01$).

According to the findings of Clochesy and colleagues,19-22 serum albumin levels, 24-hour net fluid.
balance, and left ventricular function are significantly associated with the duration of mechanical ventilatory support and weaning outcome. In our study, only 2 patients had pulmonary artery catheters in place; of these 2 patients, 1 could be weaned. The initial cardiac index of the patient who was successfully weaned was 3.5, and the PAOP was 18 mm Hg. The initial cardiac index of the patient who could not be weaned was 2.2, and the PAOP was 16 mm Hg. No other indicators of left ventricular function were available in the patients’ medical records. In addition to serum albumin levels, initial serum prealbumin levels were available on 4 patients at the time of entry in the study, 3 of whom could be weaned. The prealbumin levels indicated at least moderate deficiencies in all 4 patients. Median levels were 14.0 mg/dL (range, 9.4-17.5) for the 3

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<td>Respiration, breaths per minute</td>
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<td>Minute ventilation, L/min</td>
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*All values are medians (ranges) unless otherwise indicated. The number of patients in each cell may differ from the total number of patients in each group and if so is indicated in that cell. Initial values represent the first set of values recorded upon entry into the study. Final values represent the last set of values recorded before successful weaning for patients who could be weaned and the last set of values recorded on day 14 of the study for patients who could not be weaned.

\(^1\)Difference for final values between patients who could be weaned and those who could not were significant at \(P=.02\).

\(^2\)Ratio of respiratory frequency to tidal volume (f/VT) measured in liters per breath per minute.

<table>
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<th>Table 3</th>
<th>Initial and final values for oxygenation variables*</th>
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<tr>
<td>Variable</td>
<td>Initial values</td>
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<td>Oxygen cost of breathing, %</td>
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<td>Ratio of PaO(_2) to fraction of inspired oxygen</td>
<td>245 (175-350)(^2)</td>
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<tr>
<td>pH</td>
<td>7.44 (7.42-7.46)(^3)</td>
</tr>
<tr>
<td>PaCO(_2), mm Hg</td>
<td>40.5 (29.0-52.2)</td>
</tr>
<tr>
<td>PaO(_2), mm Hg</td>
<td>89.2 (73.2-108.5)</td>
</tr>
<tr>
<td>Base excess, mmol/L</td>
<td>3.3 (-2.0 to 0.4)</td>
</tr>
</tbody>
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*All values are medians (ranges) unless otherwise indicated. The number of patients in each cell may differ from the total number of patients in each group and if so is indicated in that cell. Initial values represent the first set of values recorded upon entry into the study. Final values represent the last set of values recorded before successful weaning for patients who could be weaned and the last set of values recorded on day 14 of the study for patients who could not be weaned.

\(^1\)Net change in oxygen consumption, measured in milliliters per minute, after a decrease in ventilator settings during weaning. For patients who did not wean completely on day 14 of the study, weaning attempts were continued by decreasing the ventilator settings. With these attempts, oxygen consumption increased.

\(^2\)Difference for values between patients who could be weaned and those who could not was significant at \(P=.005\).

\(^3\)Difference for initial values between patients who could be weaned and those who could not was significant at \(P=.04\).
patients who could be weaned and 19.9 mg/dL for the patient who could not be weaned.

Initial and final BWAP scores were nearly equivalent for both patients who could be weaned and those who could not. Although both groups had BWAP scores close to scores indicating readiness for weaning at the time of entry in the study, the final median scores declined for both groups. The most prevalent BWAP factors that were most often negative, thus contributing to decreasing scores in both groups, were the general, systemic factors: systemic hydration (weight at or near baseline weight, balanced intake and output), nourishment (albumin level >25 g/L, parenteral/enteral feedings maximized), serum electrolyte levels within normal limits (including calcium, magnesium, and phosphate), and improved general body strength/endurance (ie, out of bed, progressive activity).

Discussion

In 1998, the Third National Study Group on Weaning From Mechanical Ventilation published a refined model of weaning called the Weaning Continuum Model. The model provides an organizing framework for the study of weaning. The model is a process-oriented conceptualization of weaning that incorporates 3 stages of weaning, predictors of weaning, and patients’ responses. The study group stressed the need for descriptions of the actual clinical course of patients during weaning to test the validity of the model in order to build a knowledge base for the advancement of weaning science. The study group recommended that research be done to examine the effects of multidimensional factors and the relative contributions of these factors to the weaning process.

The purpose of this pilot study was to focus on the clinical course of older adults receiving long-term mechanical ventilation in order to determine whether these patients have multidimensional patterns of responses that indicate readiness to be weaned. A small sample size limits the extent to which any conclusions can be made about the potential significance of relationships among variables in older patients. In addition, because some variables were recorded from the patients’ records at the time of weaning, our findings are limited by the retrospective nature of chart review.

The Weaning Continuum Model includes a preweaning stage characterized by physiological instability that must resolve before a patient is ready for weaning. Within the model, short-term mechanical ventilation is defined as a period of 3 days of ventilatory support; after 3 days’ duration, ventilatory support is considered long-term. In many studies used to develop the model, the subjects were cardiac surgical patients, who generally are expected to be weaned postoperatively within 24 hours of admission. In our study, all patients underwent an extended preweaning stage before they were considered ready for active weaning. Overall, the median duration of mechanical ventilation before active weaning was 14 days (range, 7-18). This finding is similar to that of Burns et al, who reported that medical patients (n = 97)
spent more than 82% of their total patient days, or at least 11 days, in the preweaning stage. These findings suggest that it may be useful for clinicians to interpret an extended preweaning period as a "normal" stage of weaning necessary for older adults, particularly when explaining a patient's progress in weaning to the patient and his or her family members.

Initially, both patients who could be weaned and those who could not had essentially equivalent values for weaning parameters (Table 2). Patients who were successfully weaned had improvement in f/VT, although the difference in final f/VT values between the 2 groups of patients was not significant. Both groups had a wide variation of final f/VT values, a finding previously reported by Burns et al11 for 37 critically ill patients (mean age, 58 years; SD, 17 years) undergoing weaning from mechanical ventilation. Weaning parameters determined in one population of patients may not apply directly to other populations, particularly older patients. Krieger et al23 reported that for adults 70 years or older, a threshold f/VT of 130 or less improved the weaning parameters (Table 2). Patients who were successfully weaned had improvement in f/VT, which previously reported by Burns et al11 for 37 critically ill patients (mean age, 58 years; SD, 17 years) undergoing weaning from mechanical ventilation. Weaning parameters determined in one population of patients may not apply directly to other populations, particularly older patients. Krieger et al23 reported that for adults 70 years or older, a threshold f/VT of 130 or less improved the weaning outcome. In contrast, Shikora et al22 reported that a score of 56% or greater may indicate delayed for the next 48 hours. More recently, Burns et al23 determined that a threshold oxygen cost of breathing of 10% or less were weaned within 3 to 4 days, compared with a mean weaning time of 36 days in patients with an oxygen cost of breathing greater than 10%. On the basis of our findings and previous findings, the predictive value of the oxygen cost of breathing during weaning deserves further study.

Systemic variables, including a higher MAP and a lower CVP, could be used to discriminate between patients who could be weaned and those who could not. In a large sample of 162 cardiac surgery patients who were weaned from mechanical ventilation within 24 hours of admission to the intensive care unit, Goodnough Hanneman18 found a significantly lower MAP (mean, 79 mm Hg; SD, 17) in patients who could not be weaned. Others also reported that the transition to spontaneous breathing was associated with unfavorable patterns of hemodynamic responses, including increased CVP and decreased MAP.32 acute decreases in cardiac output,33 a failure to increase cardiac index,34 and sudden increases in the PAOP.35 As a variable representing pulmonary and systemic components, the BWAP scores could not be used to distinguish between patients who could be weaned and those who could not, and we found a wide variation in scores in both groups of patients. When the BWAP score was compared with 4 other weaning indices, none of the 5 were predictive of successful weaning, but all could be used to predict unsuccessful weaning; the BWAP score had the strongest negative predictive power.13 On the basis of these findings, Burns and colleagues suggest that scores of 65% or less may indicate that weaning should be delayed for the next 48 hours. More recently, Burns et al12 reported that a score of 56% or greater may indicate readiness for active weaning.

**Conclusion**

Older critically ill patients must generate enormous adaptive responses to the stressors of injury and surgery in order to regain homeostasis. Older patients have many of the risk factors for prolonged mechanical ventilation, including respiratory muscle weakness, a blunted ventilatory response to hypoxemia and hypercarbia, increased atelectasis due to diminished production of surfactant, and a greater susceptibility to infection.36 The relationship between myocardial dysfunction and massive fluid volume resuscitation, leading to third spacing of fluids, is a persistent concern of clinicians who care for older...
patients receiving long-term mechanical ventilation after traumatic and surgical injuries. Older trauma patients commonly have marginal physiological reserve, indicated by a decrease in cardiac index, difficulty in handling fluid challenges, and impaired renal regulation of fluid and electrolyte balance. Older critically ill patients may be less able to rapidly respond to resolve acid-base disturbances and to efficiently excrete medications, including anesthetics, neuromuscular blocking agents, narcotics, and sedatives. Although age alone does not predict ICU outcome among middle-aged and older adults, the need for mechanical ventilation is a significant determinant of nonsurvival in the ICU.

The multidimensional and interactive effects of these factors on weaning from mechanical ventilation most likely are more problematic for older patients than for younger patients. Thus, when clinicians wean older patients from mechanical ventilation, not only the lungs but the whole patient is warranted. Because of these limitations imposed by the small sample size in our study, we cannot make any definitive recommendations for clinical practice. Our findings suggest that further study of weaning in older critically ill patients is warranted. Future research should be directed toward identifying clusters of physiological predictors of readiness for weaning in patients receiving long-term mechanical ventilation. Such knowledge may advance weaning science through the development of weaning strategies tailored to older patients.

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